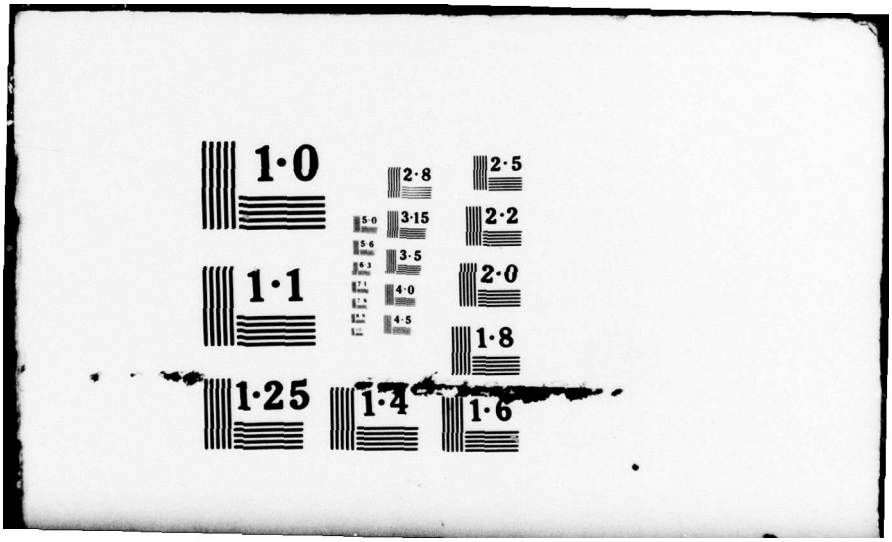
AD-A065 873 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 7/2
EXPERIMENTAL STUDY OF EXCITATION FUNCTION FOR THALLIUM ATOMS,(U)
DEC 77 L L SHIMON, E I NEPIYPOV

UNCLASSIFIED FTD-ID(RS)T-1793-77 NL

1 OF 1
ADA
065873

END
DATE
FILMED
4-79
DDC


1·0
1·1
1·25
2·8
3·15
3·5
4·0
4·5
5·0
5·6
2·5
2·2
2·0
1·8
1·4
1·6

FTD-ID(RS)T-1793-77

FOREIGN TECHNOLOGY DIVISION

EXPERIMENTAL STUDY OF EXCITATION FUNCTION FOR THALLIUM ATOMS

by

L. L. Shimon, E. I. Nepiypov
I. P. Zapisochnyy

EDITED TRANSLATION

FTD-ID(RS)T-1793-77 7 December 1977

MICROFICHE NR. FTD-77-C-001541

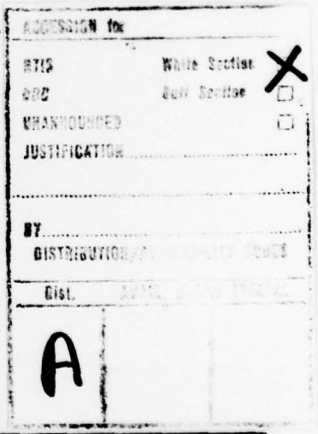
EXPERIMENTAL STUDY OF EXCITATION FUNCTION FOR THALLIUM ATOMS

By: L. L. Shimon, E. I. Nepiypov, I. P. Zapisochnyy

English pages: 6

Source: Ukrainskiy Fizicheskiy Zhurnal, Volume 17, Number 12, 1972, pages 1947-1952.

Country of origin: USSR
Translated by: LINGUISTICS SYSTEMS, INC.
F33657-76-D-0389
Myroslav Hnatyshyn
Requester: AFWL/IN
Approved for public release; distribution unlimited.



PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

EXPERIMENTAL STUDY OF EXCITATION FUNCTION FOR THALLIUM ATOMS

by
L.L. Shimon, E.I. Nepiypov , I.P. Zapisochnyy

The effective crossections and excitation functions of atoms of the first and second group of metals in the D.I. Mendelyev (1,2) periodic system has been studied most completely. Information on effective crossections and functions of elements in the third group (Al,Ga,In,Tl) are almost completely absent. This may be explained primarely by great experimental difficulties in conducting studies at high temperatures (500-1200°C), since the vapor elasticity of the said elements is low. previously, only measurements of functions of seven most intensive spectral lines of sharp diffused thallium series were conducted (3,4). However, the experiments were performed at such a low level that the obtained results have no scientific value at the present time.

Our work is the beginning of systematic studies of excitation functions and effective excitation crossections of atoms of the third group elements.

Experimental arrangement and measurements conditions

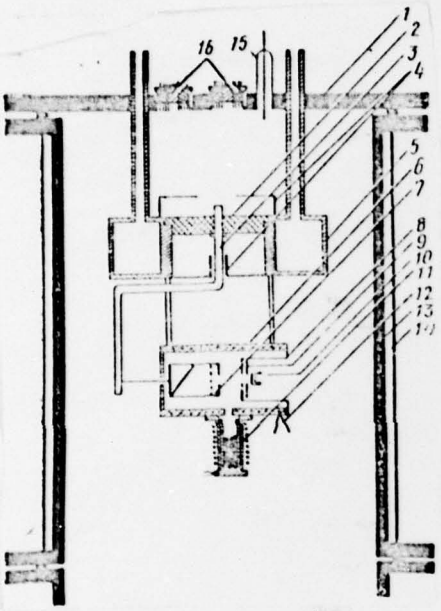
The most accepted method for studying of excitation processes and ionization of atoms of metals with low vapor elesticity is the method of atomic and electronic rays that intersect (5). However, well formed atomic ray can be obtained only at relatively low concentration of atoms in a ray. In connection with this, there appear difficulties in recording of low intensity spectral lines and lines that are located in the range of low spectral sensitivity of radiation detectors. In order to increase the radiation intensity of a shocked volume we applied a method of ~~vapour~~vapor filled cell, which was previously used in studies of metals characterized by relatively high ~~vapour~~vapor elasticity (6).

~~Vapour~~Vapor filled cell (Figure 1) consists of thoroughly warmed cofluence chamber and a reservuar behind the metallic thallium. To avoid thallium vapor condensation on a confluence chamber window, the temparature of the latter was kept 20-30°C above the temperature of the thallium reservuar.

The electronic ray was formed by means of a two anode electronic gun. Controlling the energy of electrons, the electrode performed simultaneously the roll of the confluence chamber wall.To accurately record the electronic ray current the electrical input to the electron receiver was realized through an opening in the confluence chamber wall without using any kind of insulators. Thereby, the currents which leak through isolators at temperatures above 500°C were completely eliminated. The space between the input to the electron receiver and the chamber as well as the openings of anodes were used simultaneously for pumping out the ~~vapour~~vapor filled cell.

The whole system of the vapour filled cell with the electron gun was arranged in a vacuum chamber wherein under operating conditions the residual gases pressure did not exceed $2 \cdot 10^{-6}$ torr.

Our measurements were conducted at vaour thallium pressures of $p=(1-5) \cdot 10^{-4}$ torr and electron current densities of $j=2 \cdot 10^{-4} - 1 \cdot 10^{-3}$ Atm/cm^2. Previously, thorough a series of control experiments, it was established the absence of a deforming effect of pressure on the appearance of the excitation function, and also the presence of a linear dependence of the spectral lines' intensities on the density of the electron current in wider intervals of p and i variation. Thus, all the measurements were performed at conditions of a single electron atom contact. In this, the interval of nonhomogenuity of electrons according to energy, was 1.5 eV for 90% of electron rays in the region of electron energy of 3-50 eV and incresed to 2.5 eV with the increase of the electron energy to 200-250 eV.



The intensity of spectral lines was recorded by a photoelectric method by means of FEU-18A and FEU-79

Fig.1. Schematic crossection of vacuum chamber: 1- removable flange, 2- ceramic insulator, 3- electron receiver bar, 4- protective screen, 5- water conditioner, 6- contact chamber, 7- electron receiver, 8- accelerating electrode, 9- pull out electrode, 10- oxidizing cathode, 11- metallic thallium reservuar, 12- thermovapor, 13- vacuum chamber body, 14- water cooling, 15,16- electrical inputs.

with further amplification of of the photoelectric current by a direct current amplifier U1-2. Experimental points were measured each 0.2-0.25 eV for initial sections of the curves and in the region of excitation appearance, and less frequently in the regions of great enrgies. In this, the error of the relative linemeasurements , which are the most difficult to record, did not exceed 5-7%.

Measurements results and discussion

The obtained results are shown in Fig.2-5. For ease of comparison, the relative excitation functions of all the lines are normalized with regard to maximum to one level. Each curve is an averaging result of several measurements.

Figure 2 shows excitation functions of main series lines. As it is seen, the spectral lines' intencities increase over 1-2 eV after the excitation threshold (table). In addition to the basic maximum, a second maximum in the region of 7.8-8.6 eV appears

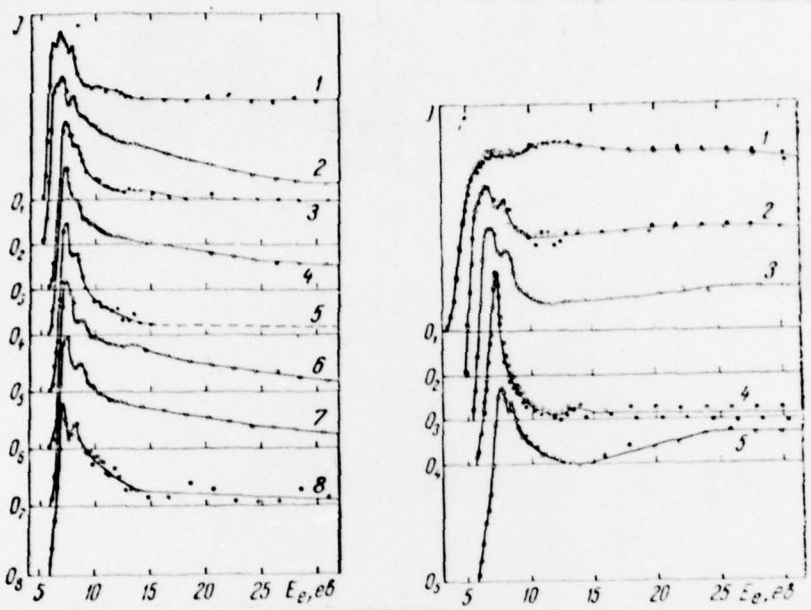


Fig. 2 **Excitation functions of main series spectral lines:**

1 — λ = 6716 Å. *2* — λ = 6539 Å. *3* — λ = 5586 Å. *4* — λ = 5520 Å. *5* — λ = 5138 Å. *6* — λ = 5111 Å. *7* — λ = 4892 Å. *8* — λ = 4679 Å.

Fig. 3 **Excitation functions of sharp series spectral lines:** 1 - λ = 3775 Å (black discs) and λ = 5350 Å (bright), 2 - λ = 2580 Å (black discs) and λ = 3229 Å (bright), 3 - λ = 2826 Å, 4 - λ = 2206 Å (black discs) and λ = 2666 Å (bright) 5 - λ = 2585 Å.

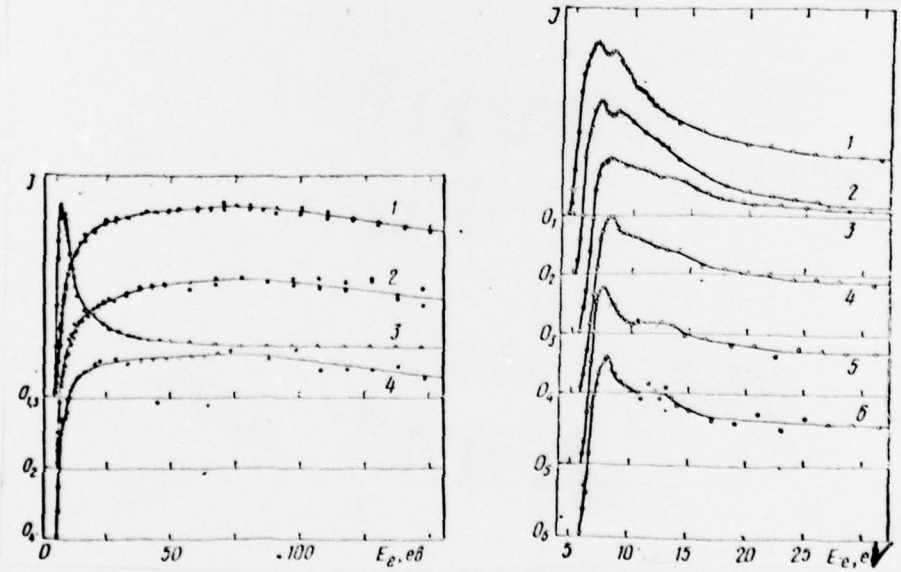


Fig. 4 **Excitation functionsof diffusion series spectral lines:** 1 - λ = 2767 Å and λ = 3529 Å (black discs), 2 - λ = 2379 Å and 2921 Å (black discs), 3 - λ = 3519 Å , 4 - λ = 2237 Å.

Fig.5 **Excitation function of diffusion series spectral lines:**

1 — λ = 3519 Å. *2* — λ = 2918 Å. *3* — λ = 2709—2710 Å. *4* — λ = 2609—2608 Å. *5* — λ = 2553—2552 Å. *6* — λ = 2517, *7* — 2517,4 Å.

to one or another extent on all the curves. A small maximum was recrded also on the end parts of the curves on excitation functions of the second part λ = 6713 and λ = 6539 A ($7^2S_{1/2}$ - $8^2P_{1/2,3/2}$). In the example of the most properly measured curves 1&2, as well as 3&4 (Fig.2) it is seen that there is a variation between the line excitatation functions, that correspond to transitions $7^2S_{1/2}$- $n^2P_{1/2}$ (black discs) and $7^2S_{1/2}$-$n^2P_{3/2}$ (the curve 5 Fig.2 could not have been measured according to electron energy above 15 eV because of the effective excitation of the equivalent ion wave line λ = 5153 Å .The curve 7 pertains to the total intensity of the complex doublet of the seventh part). The line intensity that corresponds to a transition from the upper $n^2P_{1/2}$ level, beyond the maximum excitation sharply decreases in a relatively narrow energy interval (to 15 eV beyond the threshold), after which there may be observed a nonsignificant change in the intensity up to 150 eV. At the same time, the line intensity which corresponds to the transition from $n^2P_{3/2}$ level, monotonically decreases beyond the maximum excitation, and only beginning from 30-40 eV the degree of dropping becomes insignificant, as in a case of doublet component with a $n^2P_{1/2}$ upper level.

For the lines of the sharp series (Fig. 3) characteristic are the excitation functions of doublets of the second, third, and fifth part (curves 2,3,5). They , as well as the lines of the main series, are characterized by two clearly defined maxima in the vicinity of the excitation threshold (table). Beyond these maxima there may be noticed a drop which deepens slightly and is contained in the region of higher energies at the transition from the second to the fifth part of the series (table). Further on the curves there are wide maxima , the beginning of which is also placed, and the width increases at the transition to higher parts of the series (table). The ordinate of the curves in the region of the wide maximum do not exceed the values shown in Fig. 3 in the region of 30 eV. As the electron energy increases, so accordingly the line intensity very slowly decreases beyond the wide maximum. In the region of 150 eV they are 85%, in the ragion of 300 ev they are 75% of the intensity value in the wide maximum.

Alternate from the excitation function of the second, third, and fifth part, the excitation function of the resonant lines are characteristic of wide maximum in the region of 10-15 eV. Analogous phenomenon was observed in a case of atomes of alkaline metals (1,7). In addition to the basic maximum at the output part of the curve 1 (Fig. 3) well constructed are not large maxima at 7.0 and 8.5 ev.

As for an anomalous appearance of the excitation function of the fourth part (curve 4, Fig.3) and its derivation, as it was previously said, relative to the excitation function of neighbouring parts of the sharp series, it is connected with the excitation of one of 6s-electrons (8). The curve 4 Fig.3 reconstructs excitation functions of a doublet component λ =2212 Å ($6s^26p^2P_{1/2}$ - $6s6p^24P_{1/2}$) and λ = 2672 Å ($6s^26p^2P_{3/2}$ - $6s6p^24P_{1/2}$), which appear at the excitation of 6s-electron and at its transition into higher 6p-state. This happens as a result of mixing of two states $6s6p^24P_{1/2}$ and $6s^210$

$s^2S_{1/2}$, wherein the effectiveness of state excitation, which is accountable for a doublet λ = 2212 - 2672 Å, several times exceed the excitation effectiveness state that corresponds to the fouth part of the sharp series λ = 2208 - 2666 Å.

We shall also remark, that the excitation functions of components of all sharp series dublets are identical. The same is also characteristic for excitation functions of diffusion series lines, which are characteristic by a common upper $n^2D_{3/2}$ level (Fig.4). At the same time, the excitation functions of lines that correspond to transitions from the $n^2D_{3/2}$ and $n^2D_{5/2}$ levels, vary sharply. If in the first place the excitation functions are characteristic of a very wide maximum in the region of 60-100 eV, then in another case they are characteristic of a sharp maximum near the excitation threshold. This difference is illustrated by the curves 1 and 3 Fig. 4, which relate to the line of the first part of the diffused series λ =3529 Å ($6^2P_{3/2}$-$6^2D_{3/2}$) and λ = 3519 Å ($6^2P_{3/2}$-$6^2D_{5/2}$). The author of work (9) states, that the relations between the intensities of these lines at electron energies of 15, 20 , and 30 eV are the same. Even though this statement is close to the truth, it cannot be regarded as correct one for any sort of energy. As it comes out from our measurements, in a region of small energies (to 15 eV) relations between the intensities of these lines are different .

In connection with a small split of sublevels $n^2D_{3/2}$ and $n^2D_{5/2}$, beginning with the third part of the diffusion series there were recorded total line intensities that correspond to the transitions of these levels (at equal n) to a common $6^2P_{3/2}$ level. However, since the excitation functions of such total lines are characteristic of sharp maximum (Fig.5), then, perhaps, the basic part of intensity falls on the line which corresponds to the transitions of $6^2P_{3/2}$-$n^2D_{5/2}$. On excitation functions of lines of the first two parts λ = 3519 Å ($6^2P_{3/2}$-$6^2D_{5/2}$) and λ = 2918 Å ($6^2P_{3/2}$-$7^2D_{5/2}$), in measureing of which influence of the neighbouring spectral lines was eliminated, a second maximum clearly shows beyond the basic maximum.

In this way, secondary maxima are noticed in the region of 6-9 eV (table) on the characteristic excitation functions of all series lines with the exception of the diffusion series lines, which correspond transitions $6^2P_{3/2}$-$n^2D_{3/2}$(Fig.4). It is possible, that these maxima are conditioned by a presence of contained thermal springs, which appear with the excitation of one of the 6s-electrons and its transition into higher 6p-state (energy of these therms are equal to 5.6, 6.17, 6.57, 7.7, 8.3 eV correspondingly (10). In addition to these levels above the ionization potential of thallium, there are two contained therms at 9.4 and 12 eV, which correspond to the excitation of one of the valent 6s-electrons and its transition into higher 7s-state. Perhaps, the breaks in the region 10-13 ev on the functional curves of the diffusion series excitation lines are stipulated by these these levels (Fig.5). As it should have been expected, these breaks appear stronger at the transition to higher parts in the series. Analogous picture was observed by us earler at the study of Cesium atom (7).

Номер члена серії SERIES PART No.	λ, Å	TRANSITIONS Переходи	Потенціал збудження, *e* EXCITATION POTENTIAL	Положення максимумів, *см* LOCATION OF MAXIMA
2	6716	$7^2S_{1/2}$—$8^2P_{1/2}$	5,12	6,0; 6,7; 7,8
	6539	$7^2S_{1/2}$—$8^2P_{3/2}$	5,17	6,5; 7,0; 8,1
3	5586	$7^2S_{1/2}$—$9^2P_{1/2}$	5,50	7,1; 8,1
	5520	$7^2S_{1/2}$—$9^2P_{3/2}$	5,52	7,2; 8,2
4	5138	$7^2S_{1/2}$—$10^2P_{1/2}$	5,69	7,3; 8,2
	5111	$7^2S_{1/2}$—$10^2P_{3/2}$	5,70	7,3; 8,6
5	4908	$7^2S_{1/2}$—$11^2P_{1/2}$	5,80	7,4; 8,6
	4892	$7^2S_{1/2}$—$11^2P_{3/2}$	5,81	
7	4679	$7^2S_{1/2}$—$13^2P_{1/2,\ 3/2}$	5,93	7,0; 8,3
1	3775	$6^2P_{1/2}$—$7^2S_{1/2}$	3,28	7,0; 8,5; 10—15
	5350	$6^2P_{3/2}$—$7^2S_{1/2}$		
2	2580	$6^2P_{1/2}$—$8^2S_{1/2}$	4,8	6,5; 7,8; 20—30
	3229	$6^2P_{3/2}$—$8^2S_{1/2}$		
3	2826	$6^2P_{3/2}$—$9^2S_{1/2}$	5,35	6,8; 8,0; 25—60
4	2206	$6^2P_{1/2}$—$10^2S_{1/2}$	5,61	7,3; 13,7
	2666	$6^2P_{3/2}$—$10^2S_{1/2}$		
5	2585	$6^2P_{3/2}$—$11^2S_{1/2}$	5,76	7,6; 8,4; 28—70
1	2767,8	$6^2P_{1/2}$—$6^2D_{3/2}$	4,47	60—100
	3529,4	$6^2P_{3/2}$—$6^2D_{3/2}$	4,47	60—100
	3519,2	$6^2P_{3/2}$—$6^2D_{5/2}$	4,48	7,0; 8,4
2	2379,6	$6^2P_{1/2}$—$7^2D_{3/2}$	5,20	60—100
	2921,5	$6^2P_{3/2}$—$7^2D_{3/2}$	5,20	60—100
	2918,2	$6^2P_{3/2}$—$7^2D_{5/2}$	5,21	7,3; 8,7
3	2237,8	$6^2P_{1/2}$—$8^2D_{3/2}$	5,53	60—100
	2709,2	$6^2P_{3/2}$—$8^2D_{3/2}$	5,53	8,0
	2710,7	$6^2P_{3/2}$—$8^2D_{5/2}$	5,54	
4	2609,8	$6^2P_{3/2}$—$9^2D_{3/2}$	5,71	8,0
	2608,9	$6^2P_{3/2}$—$9^2D_{5/2}$	5,71	
5	2553,0	$6^2P_{3/2}$—$10^2D_{3/2}$	5,82	7,5
	2552,5	$6^2P_{3/2}$—$10^2D_{5/2}$	5,82	
6	2516,7	$6^2P_{3/2}$—$11^2D_{3/2}$	5,89	8,0
	2517,4	$6^2P_{3/2}$—$11^2D_{5/2}$	5,89	

ЛІТЕРАТУРА

1. И. П. Запесочный, Л. Л. Шимон, Опт. и спектр., **21**, 261, 1966; **19**, 480, 1965; **19**, 864, 1965; **20**, 753, 1966; **20**, 944, 1966.
2. И. П. Запесочный, В. С. Шевера, УФЖ, **5**, 350, 1960; ДАН СССР, **141**, 595, 1961; Изв. АН СССР, сер. физ., **27**, 1044, 1963; И. П. Запесочный, О. Б. Шпеник, ЖЭТФ, **50**, 890, 1966; ДАН СССР, **160**, 1053, 1965; Опт. и спектр., **13**, 15, 1967.
3. G. Strohmeier, Zs. Phys., **107**, 409, 1937.
4. H. Fuhrman, Ann Phys., **5**, 34, 1939.
5. И. П. Запесочный, И. С. Алексахин, ЖЭТФ, **55**, 76, 1968.
6. О. Б. Шпеник, И. П. Запесочный, А. Н. Завилопуло, ЖЭТФ, **60**, 513, 1971.
7. И. П. Запесочный, Л. И. Шимон, Опт. и спектр., **16**, 929, 1964.
8. Л. И. Шимон, Э. И. Непийпов, Н. А. Гацюк, И. П. Запесочный, Опт. и спектр., **32**, вып. 5, 1040, 1972.
9. И. П. Богданова, Вестник ЛГУ, № 22, 41, 1956.
10. C. E. Moore, Atomic Energy Levels, Nat. Bur. Stand. Circ., No 467, vol. III, 1958.

Ужгородський держуніверситет

Надійшла до редакції 22.VII 1971 р.,
після доповнень — 13.XII 1971 р.

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION		MICROFICHE
A205	DMATC	1
A210	DMAAC	2
B344	DIA/RDS-3C	8
C043	USAMIIA	1
C509	BALLISTIC RES LABS	1
C510	AIR MOBILITY R&D LAB/FIO	1
C513	PICATINNY ARSENAL	1
C535	AVIATION SYS COMD	1
C591	FSTC	5
C619	MIA REDSTONE	1
D008	NISC	1
H300	USAICE (USAREUR)	1
P005	ERDA	1
P055	CIA/CRS/ADD/SD	1
NAVORDSTA (50L)		1
NASA/KSI		1
AFIT/LD		1

ORGANIZATION		MICROFICHE
E053	AF/INAKA	1
E017	AF/ RDXTR-W	1
E404	AEDC	1
E408	AFWL	1
E410	ADTC	1
E413	ESD	2
	FTD	
	CCN	1
	ETID	3
	NIA/PHS	1
	NICD	5